SHIPSHEWANA LAKE
PRE-DESIGN REPORT

January 1996

Submitted to:
Shipshewana Community
Lake Improvement
Association

Prepared by:
F. X. Browne, Inc.
Engineers • Planners • Scientists
220 South Broad Street
Lansdale, PA 19446

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A Lake Shipshewana Unconsolidated Sediment Volume Report

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1.0 Introduction

In February of 1989, International Science & Technology, Inc. (IS&T) of Reston, Virginia, submitted a draft report entitled 'Shipshewana Lake Restoration Feasibility Study' to the Shipshewana Community Lake Improvement Association (SCLIA) for the restoration of Shipshewana Lake. SCLIA wishes to pursue the recommendations of the Feasibility Study, but wants the technical information in the report verified since a final Feasibility Study was never written. For this purpose, F. X. Browne, Inc. was hired to perform a Pre-Design Study to determine the feasibility of dredging the lake and channels, stabilizing the shoreline, and constructing wetlands to reduce sediment and nutrient loads to the lake.

This report evaluates the aspects of lake dredging: sediment volume, disposal basin area, method of dredging, costs, and permits; the aspects of constructing artificial wetlands: hydrology, sites, costs, and permits; and the feasibility of dredging the five channels adjacent to the lake.

2.0 Lake Dredging

Shipshewana Lake is located in the town of Shipshewana in LaGrange County, Indiana. The lake is approximately 205 acres in size and was created in the early 1960's through the installation of a sheet pile dam. This dam discharges into Page Ditch, the only outlet of the lake. The lake has two inlets, the Mud Lake Ditch on the west side of the lake and the Sarah Davis Ditch on the south side of the lake. The Mud Lake Ditch originates at Mud Lake, and the Sarah Davis Ditch originates in the town of Shipshewana. The Cotton Lake Ditch flows into the Sarah Davis Ditch from Cotton Lake.

The Shipshewana Lake watershed encompasses approximately 4,675 acres, with the majority of the land use being agricultural, although low density residential use is increasing. The land adjacent to the lake is heavily developed with single family residences and a church camp. The eastern shore was developed around 1965. The western shore was developed around 1985. At that time, the marsh that existed at the mouth of Mud Lake Ditch was filled in with material dredged from the lake. Three channels have been excavated at the north end of the lake for lake access to new development.

2.1 Lake Depth and Unconsolidated Sediment Volume

Since F.X. Browne, Inc. did not perform the Feasibility Study, bathymetric and sediment thickness measurements were taken in October of 1995 to verify the bathymetric and sediment thickness data. A fathometer was used to sonically measure the water depth and a survey rod was used to physically measure the depth to the top of unconsolidated sediments and the depth to the top of the hard bottom. The reference point for these measurements is the top of the dam at Page Ditch. The lake depths measured by

F. X. Browne, Inc. generally agree with the depths measured by IS&T; however, the unconsolidated sediment depths measured by F. X. Browne, Inc. disagree significantly with the IS&T sediment depths. Our results were presented to the SCLIA and the IDNR in a report entitled "Lake Shipshewana Unconsolidated Sediment Volume Report". A copy of this report is presented in Appendix A. Included in the report are plans showing the F.X. Browne, Inc. measurement points and the corresponding sediment thicknesses as compared to sediment thicknesses obtained by IS&T. F. X. Browne, Inc. estimated the volume of unconsolidated sediments in Shipshewana Lake to be 1,684,000 cubic yards (1040 ac-ft). IS&T estimated the volume of unconsolidated sediments to be 551,000 cubic yards (340 ac-ft). Due to the inadequacy of the IS&T bathymetric and sediment thickness data, additional bathymetric measurements will be performed by SCLIA. These data are necessary to develop accurate bathymetric and sediment thickness maps and an accurate unconsolidated sediment volume.

Based on the IS&T Feasibility Study, the average water depth in Shipshewana Lake is approximately 6.7 feet. The existing average water depth, average sediment depth, and average water depth after dredging is shown below in Table 1 for three different dredging volume options.

Table 1
Lake Depth and Sediment Removal Information

Volume Dredged (cubic yards)	Average Water Depth Before Dredging (ft)*	Average Depth of Dredged Sediments (ft)	Average Water Depth After Dredging (ft)
551,000	6.7	1.7	8.4
1,000,000	6.7	3.1	9.8
1,684,000	6.7	5.2	11.9

*Based on IS&T Feasibility Report, verified by F. X. Browne, Inc.

2.2 Sediment Characteristics

A composite sediment sample was collected during the October 1995 site visit by mixing three discrete sediment samples. Figure 1 shows the sediment sampling locations. The composite sample was sent to an analytical laboratory for analysis. Visual inspection of the core samples indicates that the sediments consist mainly of very dark brown/gray, flocculent, highly organic material and light gray, clayey marl material. The sediment sample was analyzed for the standard parameters of particle size distribution, hazardous metals, pesticides, herbicides, nitrate and phosphorus. The results of the analyses are presented in Table 2. Table 2 also compares the analytical results to generic soil cleanup standards. Based on the particle size distribution, the composite sediment sample is 70.7% sand and 29.3 % silt and clay. The sediment sample consisted of dark gray sand and organic silt.

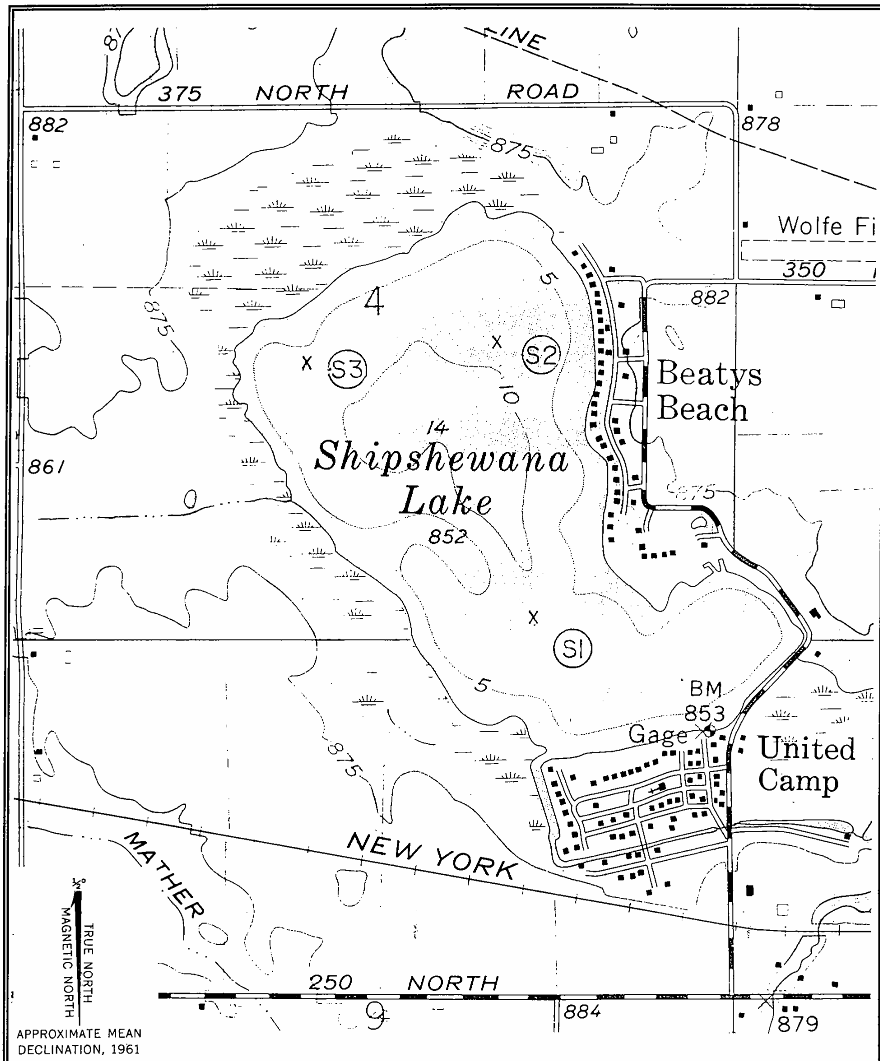


Figure 1	Sediment Sampling Locations

Table 2
Composite Sediment Sample Analytical Results

Parameter	Concentration (mg/kg)*	Soil Cleanup Standards (mg/kg)
RCRA Metals - Total Analysis Arsenic	0.466	20
Barium	<50.0	700
Cadmium	<1.00	1
Chromium	<1.00	1000
Lead	<2.00	100
Mercury	<0.070	14
Selenium	<0.200	60
Silver	<1.00	110
Nutrients Nitrate as Nitrogen	<2.1	-----
Phosphate as phosphorus (solid)	27	-----
Herbicides 2,4,5 - TP (solid)	<0.0002	600
2,4 - D (solid)	<0.0005	700
Priority Pollutant List Pesticides a - BHC	<0.0080	-----
b - BHC	<0.0080	-----
d - BHC	<0.0080	-----
g - BHC (Lindane)	<0.0080	0.52
Heptachlor	<0.0080	0.15
Aldrin	<0.0080	0.040
Heptachlor epoxide	<0.0080	-----
Endosulfan I	<0.0080	340
Endosulfan II	<0.0160	340
Dieldrin	<0.0160	0.042
Endrin	<0.0160	17
Endrin Aldehyde	<0.0160	-----

Table 2 (continued)
Composite Sediment Sample Analytical Results

Parameter	Concentration (mg/kg)*	Soil Cleanup Standards (mg/kg)
4,4' - DDE	<0.0160	2
4,4' - DDD	<0.0160	3
4,4' - DDT	<0.0160	2
Endosulfan sulfate	<0.0160	-----
Chlordane	<0.0800	4
Toxaphene	<0.1600	0.10
PCBs PCB - 1016	<0.0800	0.49
PCB - 1221	<0.0800	0.49
PCB - 1232	<0.0800	0.49
PCB - 1242	<0.0800	0.49
PCB - 1248	<0.0800	0.49
PCB - 1254	<0.1600	0.49
PCB - 1260	<0.1600	0.49

WHAT DOES THIS MEAN

* <X = Not detected; value indicates minimum quantifiable limit.

SEE PLANNER 2-19-(1)

2.3 Sediment Disposal Site Evaluation

Three potential disposal sites were visited in October 1995. These sites were identified by the SCLIA and are shown in Figure 4. Site 1 is located west of the lake and west of Vacation Way on approximately 27 acres of gently rolling farmland. Site 2 is located northwest of the lake and north of Vacation Way on approximately 9 acres of moderately sloped farmland. The farmland is just past a wetland area adjacent to the north shore of the lake. Site 3 is located southwest of the lake and west of the church camp on approximately 2.4 acres of moderately sloping farmland. Site 3 is too small to be a feasible sediment disposal site. The two larger sites northwest and west of the lake presented the greatest potential, so they were surveyed by an Indiana registered surveyor in order to evaluate their capacity. The capacities of Sites 1 and 2 are presented in Table 3.

Table 3 Sediment Disposal Area Capacities		
Site No.	**Capacity (cubic yards)**	**Capacity (acre feet)**
1	564,700	350
2	121,000	75

Site 1 is a feasible disposal site for sediments from Shipshewana Lake. It is located close to the lake (approximately 600 feet from the lake to the middle of the site), covers about 27 acres of rolling farmland, and has a capacity of approximately 350 ac-ft, which is about one third of the capacity required for the total sediment volume. The site capacity was calculated assuming that 20 foot high berms will contain the sediment and cover 6 acres of the site, and that the sediments will be 17 feet deep. The supernatant from the sediment slurry will be returned to the lake. A drainageway regulated by the local Drainage Board runs through a field tile system on the site. Any work done in the drainageway will require the approval of the Drainage Board.

Site 2 is not a feasible disposal site for sediments from Shipshewana Lake. It is located close to the lake, but slopes toward the lake with an elevation difference of 30 feet. The side closest to the lake abuts a wetland area. The site covers only 9 acres and has a capacity of 75 ac-ft. The site is small and would require a tremendous amount of earthwork to provide a comparably small volume for sediments; therefore, this site was rejected as a feasible disposal area.

Based on the disposal sites identified by the SCLIA, Site 1 is the only site that is feasible for disposal of sediments from Shipshewana Lake. This site could handle 350 acre feet (564,700 cubic yards) of lake sediments.

2.4 Dredging Method Selection

Lake dredging can be performed mechanically or hydraulically. Mechanical dredging typically involves lowering the lake to dewater the sediment and then using conventional earth-moving equipment such as bulldozers or draglines to excavate the sediment. The sediments must then be hauled to the disposal area. Hydraulic dredging involves using a floating barge with a cutterhead which dislodges the sediment. The sediment mixes with water, is pumped to the water surface and is transported via pipelines to the disposal/sedimentation basin. The sediment settles out of the slurry and the clear water is returned to the lake via pipeline. Figure 2 shows a typical hydraulic dredge (Barnard 1978) and Figure 3 shows a typical disposal/sedimentation basin (Montgomery 1978).

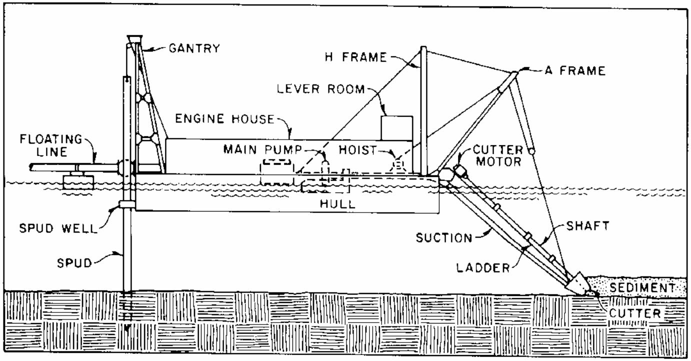


Figure 2	**Typical Hydraulic Dredge**

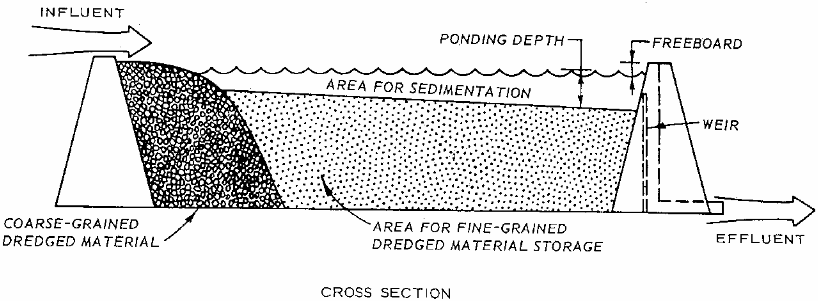


Figure 3	**Typical Disposal/Sedimentation Basin**

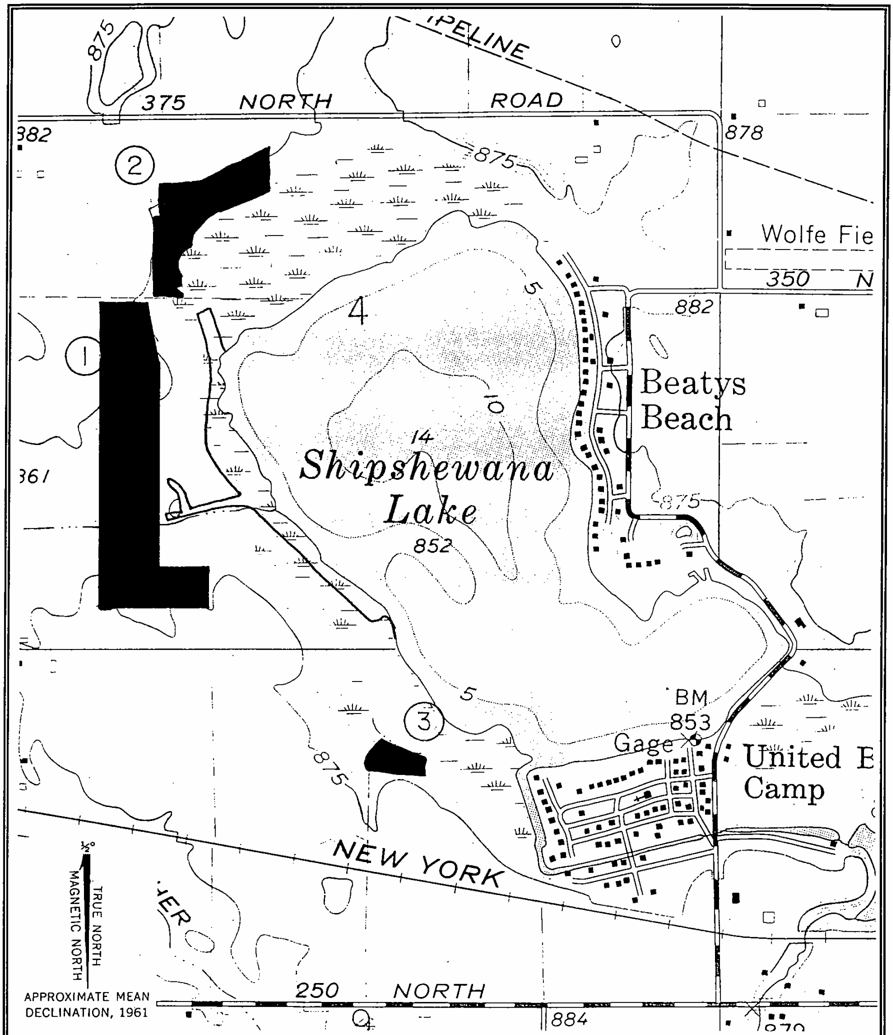


Figure 4	Potential Sediment Disposal Site Locations

The dam at the outlet of Shipshewana Lake allows the lake to be lowered only 3 feet. Therefore, dewatering the sediments and using mechanical dredging methods, as described in the IS&T Feasibility Study, is not feasible. Hydraulic dredging has a high mobilization cost, but for large sediment volumes this cost is defrayed and there are no hauling costs involved, making hydraulic dredging economically favorable. Hydraulic dredging is recommended for Shipshewana Lake as long as a sufficient area for disposal/sedimentation and an appropriate pipeline location are available.

Perhaps "such as the 27 acre site "1" or similar sites"...

I the 27 acre site considered sufficient for dredging purposes.

2.5 Permit and Approval Requirements

The following permit and approval requirements have been identified by contacting representatives from regional, state and local agencies. A Soil Erosion and Sedimentation Control Plan will need to be approved by the LaGrange County Soil and Water Conservation District. A permit for Construction In or On a Public Freshwater Lake (State form 43008) will have to be received from the Indiana Department of Natural Resources (IDNR) Division of Water. A Department of the Army Permit Application (ENG Form 4345), will need to be submitted to the United States Army Corps of Engineers Detroit District in order to obtain an Individual Permit (404 Permit). The Corp of Engineers has four months to evaluate the application. Water Quality Certification (Section 401 Permit) from the Indiana Department of Environmental Management (IDEM) will be necessary. The public notice from the Individual Permit serves as the application for Water Quality Certification. A National Pollution Discharge Elimination System Permit (NPDES) will be necessary if the sedimentation basins require over 5 acres of earth disturbance. A permit from the United States Forest Service may be necessary depending on the route of the pipelines. Approval from the LaGrange County Drainage Board will be necessary for any work done in regulated drains or in the seventy-five foot right-of-way.

What permit?

2.6 Alternatives to Lake Dredging

The two main benefits of lake dredging include increasing the lake volume and removing sediments that contain high levels of nutrients. However, these nutrients are only released during anoxic (zero oxygen) conditions. Alternatives to lake dredging that may reduce or eliminate the release of phosphorus from lake sediments include hypolimnetic (lake bottom water) aeration to aerate the bottom waters of the lake and alum addition to seal the sediments.

Inducer

In order to determine if hypolimnetic aeration or alum addition will work, the oxygen dynamics in Shipshewana Lake during July and August must be known. The IS&T Feasibility Study only includes one set of dissolved oxygen and temperature profiles at six sites in the lake in September. These data indicate that the shallower areas of the lake do not thermally stratify and the dissolved oxygen is similar throughout the water column. In the deeper areas, there is some thermal stratification; however, dissolved oxygen levels do not reach zero (the lowest dissolved oxygen reading is 2.9 mg/L).

Hypolimnetic aeration is the aeration of the lakes lowest and coldest waters only. A hypolimnetic aerator is designed to oxygenate the colder bottom water without mixing it with the warmer water near the surface of the lake. By re-oxygenating the bottom waters, phosphorus release from the sediments is minimized. The September data in the IS&T Feasibility Study indicates that the lake does not thermally stratify and the extent of anoxia is minimal. The size and shape of the Shipshewana Lake likely results in frequent wind induced mixing events that prevent thermal stratification and oxygen depletion. Therefore, hypolimnetic aeration does not appear to be a feasible alternative.

Alum addition is the addition of aluminum sulfate to the surface of the lake. The aluminum combines with phosphorus in the water column and settles to the bottom of the lake. During this process, all particulate matter is stripped from the water column. The aluminum floc remains in the top few centimeters of the sediments and prevents phosphorus release. Over time the effectiveness of the alum application in preventing sediment phosphorus release is diminished as the chemical bonding sites are used up and the bottom of the lake is covered with new sediments. The effective life of alum treatment is short (less than five years) in lakes that are shallow, do not stratify, and have high external sediment and nutrient loads. Although numerous management practices have been installed within the Shipshewana Lake watershed, the sediment and phosphorus loadings to the lake are still high; therefore, alum treatment does not appear to be a feasible alternative. The cost of alum treatment is approximately $300 to $500 per acre (Cooke, 1993). Therefore, the approximate cost for alum addition for Shipshewana Lake is $81,000 for a one time treatment.

3.0 Constructed Wetlands

Constructed wetland systems provide a low-cost, low-energy, yet highly effective method of treating stormwater runoff from urban and agricultural areas. Stormwater runoff from such areas generally carries very high concentrations of sediments, nutrients, and other pollutants in comparison with undeveloped areas. Constructed wetland systems are carefully designed to meet the specific requirements for the type of stormwater runoff that they must treat. Pollutants which threaten the water quality of downstream waterways are effectively removed within these systems through settling, filtration and biological treatment processes. This treatment option provides excellent removal of pollutants, while requiring minimal operational attention. The periodic cleaning of sediment traps is the only maintenance required by a properly functioning system.

Other benefits of constructed wetland systems include the creation of wildlife habitat, aesthetic enhancement, and the expansion of environmental education curriculums. Wetland systems are dynamic and diverse, providing an excellent tool for environmental education.

3.1 School Site Constructed Wetlands

The existing constructed wetland area in the rear of the Shipshewana Elementary School is unsatisfactory for the treatment of urban stormwater from its 50 acre watershed (see Photos 1 and 2). This system should be reconstructed and enlarged to provide adequate treatment with relatively simple, low-cost maintenance. A sediment forebay is needed to settle suspended particles from incoming stormwater to prevent clogging of the entire system. This forebay will be sized accordingly for accessible, periodic removal of accumulated sediments by small equipment. The remainder, and largest portion of the wetland system, will be enlarged and vegetated. This portion will be responsible for the biological removal of nutrients and other pollutants, as well as the further settling of fine suspended particles. An example of a typical sediment forebay followed by a wetland treatment system is shown in Figure 5.

2.4% OF WATERSHED

The existing wetland is approximately 1.2 acres in size and consists of a mud flat area surrounded by wetland vegetation. This wetland system does not function well to remove sediments and nutrients from the stormwater directed to the site. Based on the methodology for sizing wetlands presented by Schueler, 1992, the area needed to provide adequate treatment for the 50 acres draining to the existing stormwater management facility located behind the school is 0.5 acres. This area was calculated assuming that the 50 acres drainage area is approximately 90 percent impervious. The 6 month, 24 hour storm volume was calculated to be 1.7 inches using information provided in the Soil Conservation Services TR-55 Model and in "Constructed Wetlands for Storm Runoff Water Quality Control" (Horner, 1993). Since approximately 4.0 acres is available at the school site for a constructed wetland system, this is a feasible site. Based on the calculations, the constructed wetland only needs to be 0.5 acres; however, if the wetland system is designed to be larger and have a longer hydraulic residence time, the removal efficiencies will increase, and more dissolved pollutants such as nitrogen and phosphorus will be removed (Horner, 1993). We recommend that the existing 1.2 acre wetland be replaced with a 2 acre constructed wetland that will consist of a forebay to settle out large solids, a wetland zone to remove smaller sediments and nutrients, and a micro-pool (exit pond) to remove additional suspended matter. The final design of the wetland system will include a hydrologic evaluation to determine if a bypass is needed for larger storms so that the wetland system is not washed out.

CAN I GET A COPY OF THIS

good

Photo 1 : View of the existing school wetland.

Photo 2 : View of the existing school wetland.

3.2 Sara Davis Ditch Constructed Wetlands

WHICH STREAM SERVES THE TOWN ? SCHOOL DITCH OR SARA DAVIS DITCH.

The Sara Davis Ditch which flows from Cotton Lake to Shipshewana Lake is a county regulated drainageway south of Route 250. A 750 foot section of this "ditch" adjacent to and south of Route 250 currently serves as a water conveyance channel and provides no pollutant removal. In fact, the current erosion of this ditch during stormflows is contributing nutrient and sediment pollution to Shipshewana Lake. A properly designed constructed wetland system in this area would be capable of removing high concentrations of nutrients, suspended particles, and other pollutants from approximately 2,100 acres of the Shipshewana Lake watershed. The drainage easement is 100 feet wide at this site; therefore, a 1.7 acre area is available for a constructed wetland system.

The wetland area required for treating the drainage from the 2,100 acre watershed to the Sara Davis Ditch site is 15 acres based on standard calculations for sizing wetlands. However, the topography and peaking factors for this agricultural portion of Indiana are significantly different than average conditions, and standard runoff equations do not adequately reflect the actual runoff in the area. According to Rex Pranger, LaGrange County Engineer, there is significant depression storage within the watershed by natural depressions, man-made farm ponds, and Cotton Lake; therefore, the time of concentration to the Sara Davis Ditch location is extremely long and storm peaks are spread out over time. Mr. Pranger indicated that the water level in the Sara Davis Ditch at the proposed wetland site does not increase significantly during storm events. Occasionally during a very large storm event or during a high snow melt event, the water in the Sara Davis Ditch only slightly overflows its banks.

.08%

Based on the above information and on our field evaluation of this site, we feel that the 1.7 acre area that is available at this site would be adequate for a constructed wetland treatment system. While the final design of this wetland systems is being performed, we recommend that the water flow in the ditch be monitored during rain events. In fact, Mr. Pranger volunteered to assist in the monitoring of stream flows. Based on these flow measurements, we may need to design a bypass for excess water during large rain events so that the wetland is not scoured by periodic high flows. → IS COMMON PRACTICE!

A constructed wetland system specifically for the removal of agricultural associated pollutants can be designed for this area. Such a system would provide a low-cost, low-maintenance process that would remove high concentrations of nutrients, suspended particles, and other pollutants from stormwater before entering Shipshewana Lake. A sediment forebay will be appropriately sized to attain adequate removal of suspended particles. The remaining portion of the system will be vegetated for the biological removal of nutrients and other pollutants. Instead of a single channel running uncontrolled through the area, the system would detain and control stormflows, evenly discharging water to a densely vegetated, meandering system. See Figure 6 for a typical meandering wetland system. Treatment is essential at this location since there is significant agricultural activity in this portion of the watershed. Fertilizing and soil disturbance associated with farming methods used by local farming operations introduces high concentrations of nutrients to the Sara Davis Ditch.

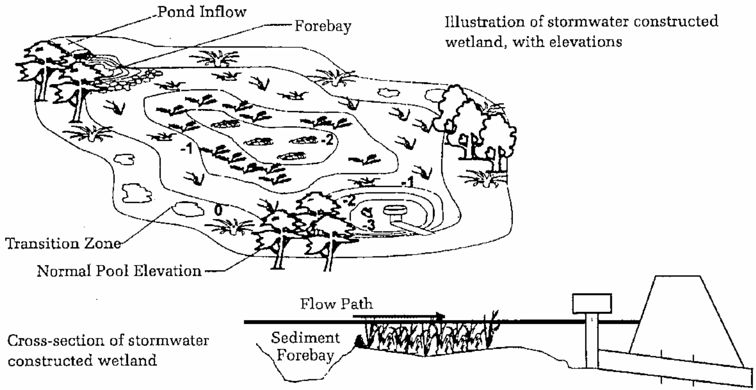


Figure 5	**Typical Forebay Constructed Wetland System (from Shaver and Maxted 1994)**

3.3 Permit and Approval Requirements

Enhancement of the wetland area at the Shipshewana Elementary School Site will require a federal permit, Nationwide Permit No. 27 - Wetland Creation/Restoration. Cooperation with the Natural Resources Conservation Service and the Fish and Wildlife Service is an integral element of the permit requirements. Therefore, both agencies will be notified of our intent and solicited to participate in any fitting manner. Approval of the final plans for this site is required from the LaGrange County Drainage Board since the proposed project will be located within a county drainage easement. A Soil Erosion and Sedimentation Control Plan approved by the LaGrange County Soil and Water Conservation District will also be required.

Creation of a wetland system at the Sara Davis Site will also require a federal permit, Nationwide No. 27 - Wetland Creation/Restoration. Again, cooperation with the Natural Resources Conservation Service and the Fish and Wildlife Service is an integral element of the permit requirements. Both agencies will be notified and solicited to participate in any fitting manner. A permit will also be required from the Indiana Department of Natural Resources to conduct work in a floodway. Approval of the final plans for this site is required from the LaGrange County Drainage Board since the proposed project will be located within a county drainage easement. A Soil Erosion and Sedimentation Control Plan approved by the LaGrange County Soil and Water Conservation District will also be required.

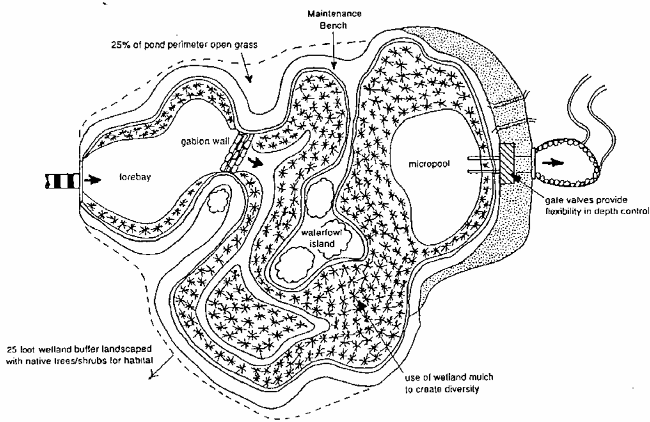


Figure 6

Typical Meandering Constructed Wetland System (after Schueler 1992)

4.0 Channel Dredging Feasibility

There are five channels adjacent to Shipshewana Lake. Depths to the top of unconsolidated sediments and to the top of the hard channel bottom were measured using the method described in the Shipshewana Lake Unconsolidated Sediment Volume Report. The channels were numbered starting with the Mud Lake Ditch and proceeding clockwise around the lake. The estimated sediment volumes are as follows:

Channel	Estimated Sediment Volume (cubic yards)
1	7,394
2	3,043
3	1,570
4	5,032
5	4,751
Total	21,790

The channels would require different dredging equipment than Shipshewana Lake and would require 13.5 ac-ft of disposal area. At this time we do not recommend dredging the channels to improve the water quality of the lake, since the sediment volume is a fraction of the sediment volume present in the lake itself.

5.0 Shoreline Stabilization

As mentioned earlier, the western shore of the Shipshewana Lake was developed around 1985, at which time wetland soils were dredged from the lakeward edge of the marsh that existed at the mouth of the Mud Lake Ditch to fill the landward edge of the same marsh. The resulting filled area is only 1-2 feet above the normal lake elevation and is very unstable. The fill material and original, underlying material is highly organic in nature (listed as "muck" in the LaGrange County Soil Survey), and is very poorly drained. The shoreline of this filled area is highly erodible, with large pieces of muck falling into the lake where vegetation has not been able to become adequately established (see Photos 3 and 4). In some areas, wave action is too intense, and in others landowners do not allow such vegetation to exist. Many residents have constructed various types of bulkheads to prevent this shoreline erosion. However, the soils are so unstable that the bulkheads

Photo 3 : View of shoreline erosion along western shore of Shipshewana Lake.

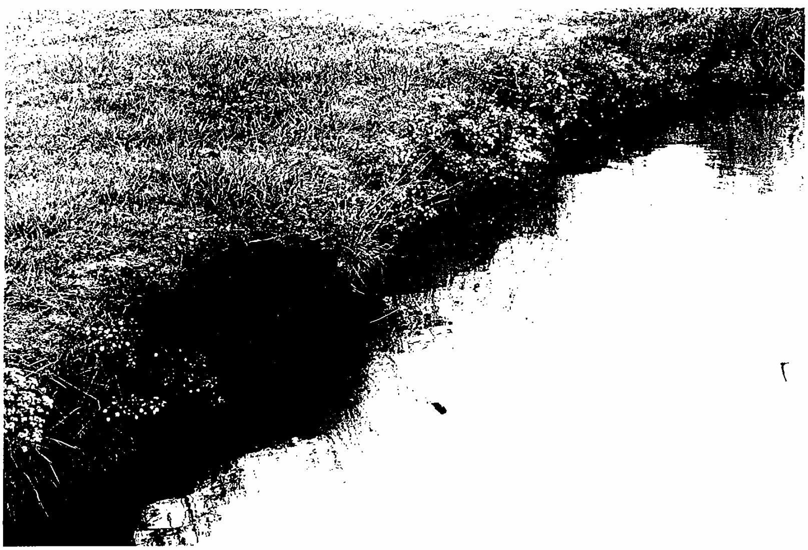


Photo 4 : View of shoreline erosion along western shore of Shipshewana Lake.

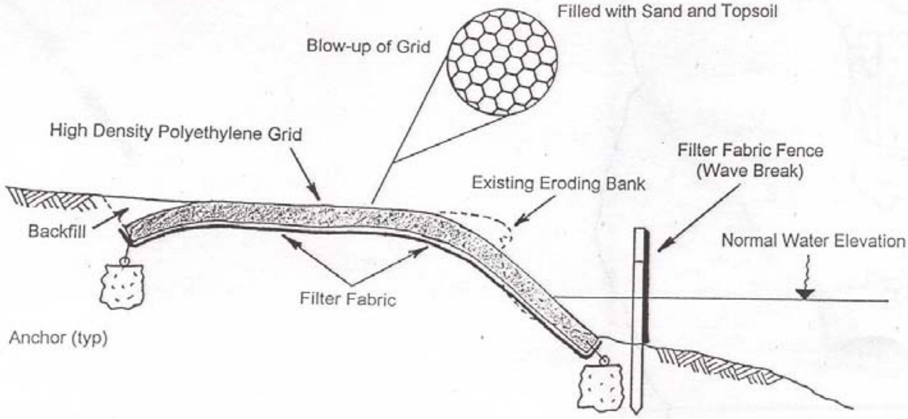
themselves fall toward and into the lake within a few years. Figure 7 shows the location and lengths of shoreline that require stabilization.

Shoreline stabilization can be accomplished through bioengineering techniques or a combination of bioengineering and structural techniques. Common, less expensive structural solutions are ineffective since there is no integrity to the soils comprising the filled area, as may be seen where bulkheads and rip-rap have failed. More involved structural techniques capable of enduring the site conditions would not be cost-effective. Bioengineering techniques involve the use of natural substrates such as coir fiber bundles or coir fiber mats in combination with select vegetative species. The coir fiber products provide temporary stabilization until the vegetation becomes established with fully developed root systems to assume erosion control. Proposed bioengineering techniques use ground-level and/or shrubby vegetation in areas where access to and view of the lake is not as important. A combination of bioengineering and structural techniques may be used in other areas where shoreline vegetation is not found acceptable. In these areas, a 6 inch thick High Density Polyethylene plastic grid may be used as the structural medium. The grid is like a "honeycomb" which is filled with select substrate and planted with select vegetation. Properly installed and planted, the grid should be unnoticeable and will provide access to the water with an unimpeded view of the lake. The section of the grid which is located on land, above the water elevation, may be mowed and maintained to within 1-2 feet of the water's edge. Figures 8 and 9 show conceptual designs for conventional and bioengineering shoreline stabilization measures applicable to Shipshewana Lake.

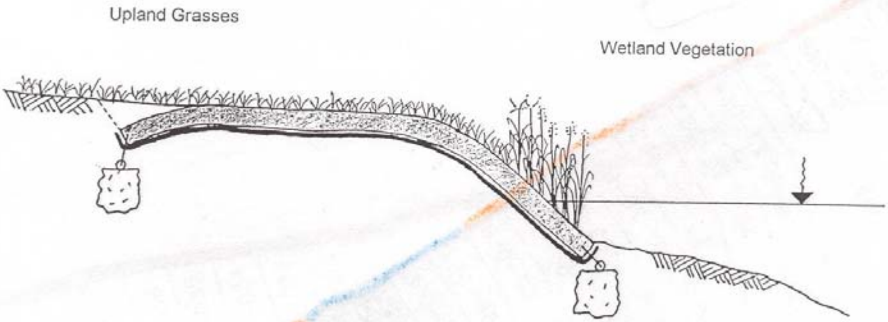
Shoreline stabilization will be addressed in two phases. Phase I will address those lengths of shoreline with severely eroded banks, approximately 1905 feet. Phase II will address those lengths of shoreline with structures that should remain intact for the next 3-5 years, approximately 780 feet. Approximately 270 feet of shoreline between the northwest channel and the cul-de-sac of 4th of July Avenue do not need to be stabilized, including the shoreline in the park area. However, it is important to note that future improvements to this area may result in the same types of erosion problems. Figure 7 shows the length of shoreline involved in each phase.

Figure 7

Shipshewana Lake Shoreline Stabilization

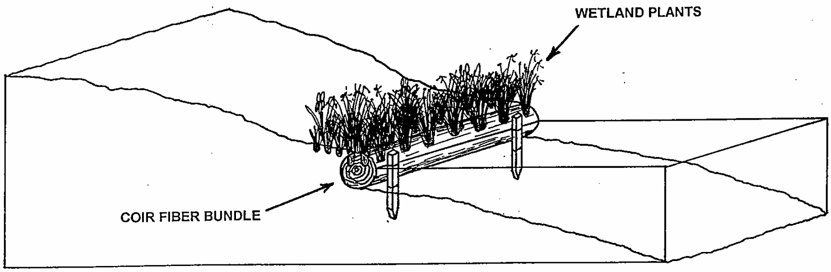


BANK STABILIZATION WITH
HIGH DENSITY POLYETHYLENE GRID
(CONSTRUCTION)

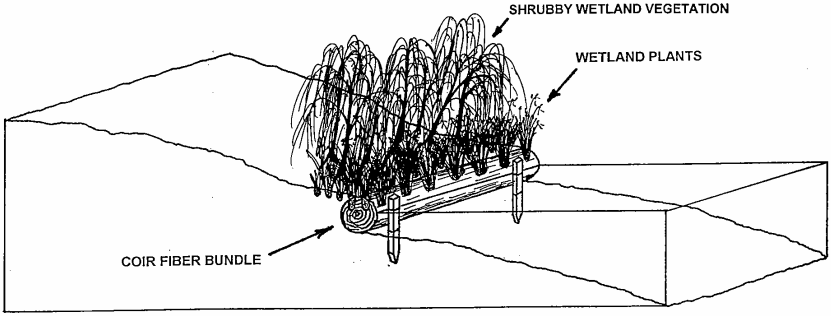


BANK STABILIZATION WITH
HIGH DENSITY POLYETHYLENE GRID
(POST-CONSTRUCTION)

Figure 8	**Shoreline Stabilization Techniques**



VEGETATIVE BANK STABILIZATION



VEGETATIVE BANK STABILIZATION

Figure 9	**Shoreline Stabilization Techniques**

6.0 Cost Estimates

Project costs have been prepared for lake dredging, constructed wetlands, and shoreline stabilization. Costs are broken down into engineering design and permitting costs, construction costs, and construction observation costs. The permitting costs do not include permit application fees. Project costs are presented in Table 4.

Dredging costs are provided for three options: dredging 551,000 cubic yards, 1,000,000 cubic yards, and 1,684,000 cubic yards. The engineering design and permitting costs are based on the assumption of designing and permitting one disposal site.* The design and permitting costs would increase if more than one disposal site was used for sediment disposal. The construction observation cost assumes a construction period of five months with a part-time inspector at approximately four hours per day for a maximum of 100 days. It also assumes the use of one disposal site. The use of additional disposal sites may increase the construction observation cost, depending on the specific operating characteristics of the dredging project.

SO THEY ARE LIMITED TO FIRST OPTION

LOCAL OR F.X. BROWN

The state may require some form of water quality monitoring during the dredging of the lake. The specific water quality monitoring program, if required at all, will be determined during the permitting process. Accordingly, a cost for a water quality monitoring program is not included in the costs listed below.

All design, permitting and construction observation and construction costs were calculated in 1996 dollars. If any of these are postponed beyond 1996, the costs for these postponed activities will increase.

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Table 4
Project Costs

	Sediment Volume (Cubic Yards)		
Lake Dredging	**551,000**	**1,000,000**	**1,684,000**
Engineering Design & Permitting	$ [1] 50,200	$ 50,200	$ 50,200
Construction Observation	$ [2] 20,000	$ 20,000	$ 20,000
Dredging & Disposal Basin Construction	[3] $1,319,000 $2.39 per yd³	$2,269,000 2.27 per yd³	$3,486,000 2.07 per yd³

Constructed Wetlands	Cost
Engineering Design and Permitting	$ [1] 26,700
Construction - School Wetland	[3] 47,000
Construction - Sara Davis Ditch Wetland	[3] 48,000
Construction Observation	[2] 10,000
Total	$ 131,700

Shoreline Stabilization	Cost
Engineering Design and Permitting	$ [1] 12,100
Construction (2,685 linear feet)	[3] 48,000
Construction Observation	[2] 4,000
Total	$ 64,100

[1] TOTAL DESIGN - $89,000

\# [2] TOTAL CONSTRUCTION ADMIN. - $34,000/400 hr = $85 an hour.

[3] TOTAL CONSTRUCTION - 1.462 million

→ COULD THERE BE A SAVINGS IF ALL WERE INSPECTED SIMULTANEOUSLY BY 1 INSPECTOR.

7.0 Conclusions and Recommendations

7.1 Dredging

Since the volume of sediments in Shipshewana Lake is significantly larger than originally estimated (1,684,000 cy versus 559,000 cy), the estimated cost for dredging the entire lake has significantly increased. Dredging the entire 1,684,000 cubic yards of sediment is not a feasible option due to the high cost and the lack of sufficient disposal area volume. The only suitable disposal basin area, identified by the SCLIA, has a volume of 564,700 cubic yards. Therefore, we recommend that the SCLIA dredge approximately 551,000 cubic yards of sediment from Shipshewana Lake. We recommend that the sediments be dredged using a hydraulic dredge and be pumped to Disposal Area #1 for dewatering. Decant water from the disposal basin will be directed back to Shipshewana Lake. By dredging 551,000 cubic yards of sediment from the lake, the detention time in the lake and the volume of the lake will increase. In addition there will be more dilution in the lake and the amount of phosphorus in the lake sediments will be decreased.

If the 551,000 cubic yards of sediment are dredged evenly across the lake, the average depth of the lake will be increased by approximately 1.7 feet. As an alternative, spot dredging could be performed to remove sediments from separate areas of the lake. If spot dredging is selected, areas of extensive deposition can be identified and selected for dredging after a detailed bathymetric map produced.

One option is to fill the disposal area adjacent to the lake (Site #1), allow the sediment to dewater, haul the dewatered sediment to a second disposal site, and refill the original disposal site. This option will increase the total construction cost for dredging.

A second option would be to fill the disposal area adjacent to the lake, allow the sediment to dewater and to sell the dried sediment to government agencies (such as the Department of Transportation), developers, local builders, or the general public. The income from the sale of the sediment could be used to dredge additional sediment from the lake.

A third option, if the sediment could not be sold, would be to allow government agencies, developers, and the general public to haul the sediment away for free. This would free up the disposal basin for additional dredged sediments in the future. Obviously, the second option, selling the sediment would be preferable. However, unlike the first option, the Association would not have to pay for sediment hauling to another site.

7.2 Constructed Wetlands

We recommend that the constructed wetlands be created before or at the same time the lake is dredged. Constructed wetlands will reduce the sediment and nutrient loads entering the lake for a relatively low cost. Although constructed wetlands do not provide a visible and immediate improvement in water quality, they are an excellent form of stormwater management that will prevent further degradation of Shipshewana Lake. We recommend that a 2.0 acre wetland be constructed at the school site. We also recommend that a 1.7 acre wetland be constructed at the Sara Davis Ditch site.

7.3 Shoreline Stabilization

Shoreline stabilization is an important aspect of the restoration of Shipshewana Lake. We recommend that the stabilization be done in two phases. Phase I includes the stabilization of shoreline with severe erosion problems as soon as possible, and Phase II includes the stabilization of shoreline with moderate erosion problems within the next few years. Shoreline stabilization should be accomplished by installing bioengineering techniques such as coconut fiber rolls planted with various types of plants that have extensive root structures. If homeowners are opposed to an "all vegetation" solution, the installation of a geoweb grid system in combination with less vegetation at the land/water interface is a good alternative that should provide a stable shoreline.

7.4 Environmental Education Program

The Shipshewana Community Lake Improvement Association should work with the local school district to implement an environmental education program. The program could be modeled after the program developed by F. X. Browne, Inc. for the Wallenpaupack Area School District in Pennsylvania.

The program could consist of an intensive 4 to 5-days of field and classroom activities where the students would perform lake, stream and wetland surveys, and tour existing Best Management Practices (BMPs) such as hog farm manure treatment systems, agricultural management practices, constructed wetlands, and shoreline stabilization projects. They would also visit a wastewater treatment plant.

Classroom activities would consist of analyzing field data, identifying lake phytoplankton (algae), and performing related activities in art, science, math, english, and other subjects.

The environmental education manual prepared by F. X. Browne, Inc. would be used as the course "textbook". We are presently developing a better, more comprehensive environmental education manual under an EPA 319 Grant.

The Environmental Education Program, however, should not be limited to school students. It should also be made available to adults, especially members of SCLIA. It's important for both adults and children to understand lake and watershed dynamics. And it's fun!

7.5 Potential Funding Sources

During the design stage of this project, F. X. Browne, Inc. will investigate specific sources of funds for the implementation of the activities recommended in this report. In general, however, the main sources of funds include the State of Indiana T-By-2000 Lake and River Enhancement Grants, EPA 314 Clean Lakes Program Grants, EPA 319 Nonpoint Source Grants, state and federal line item grants, and local funding from the municipality or county.

Presently, the EPA Clean Lakes Program does not have funds appropriated for lake restoration projects. EPA is considering combining the Clean Lakes Program with the 319 Nonpoint Source Program. The 319 Program is a viable source of funds that could be used for implementing management practices such as constructed wetlands and streambank stabilization. These funds can also be used for developing and implementing public education programs. If the EPA integrates the 314 Clean Lakes Program into the 319 Nonpoint Source Program, then lake dredging will probably be funded under the 319 Program.

In some cases, funds can be made available through special line-item grants provided by either the state or federal government. These special funds are usually earmarked for specific activities in a particular watershed. They usually do not require local matching funds.

There are other federal programs that offer grants for watershed management, such as the EPA 104(b)(3) Program and the EPA Environmental Education Program. All of these potential funding sources will be further investigated during the design stage of this project.

8.0 References

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Appendix A

Lake Shipshewana Unconsolidated Sediment Volume Report

LAKE SHIPSHEWANA UNCONSOLIDATED SEDIMENT VOLUME REPORT

November 7, 1995

Submitted to:
Shipshewana Community
Lake Improvement
Association

Prepared by:
F. X. Browne, Inc.
220 South Broad Street
Lansdale, PA 19446

1.0 Introduction

A bathymetric survey was conducted by International Science & Technology, Inc. in September of 1988. A fathometer was used to sonically measure the depth to the top of unconsolidated sediments and the depth to the top of the hard lake bottom. These measurements were used to produce a sediment thickness map. From this map, the volume of unconsolidated sediments was calculated at 551,357 cubic yards. These results were presented to F. X. Browne, Inc. in a Draft Report of the Shipshewana Lake Restoration Feasibility Study dated February 3, 1989. F. X. Browne, Inc. staff visited Shipshewana Lake on October 6-9, 1995 to perform a Pre-Design Study, which included evaluating the unconsolidated sediment volume reported in the Feasibility Study Draft Report.

2.0 Methodology

F. X. Browne, Inc. prepared a scaled version of the sediment thickness map from the Feasibility Study to use as a guide and to verify the sediment thickness measurements. During the site visit, F. X. Browne, Inc. used a fathometer to measure the depth to the bottom of the lake along the same transects that were followed by I.S. & T. In addition, a survey rod was used to physically measure the depth to the top of unconsolidated sediments and the depth to the top of the hard bottom at eighteen points throughout the lake, and in the five channels adjacent to the lake. The survey rod was lowered into the water until the sediment could be felt, and this depth was recorded as the depth of water. The survey rod was then pushed through the unconsolidated sediment until it could no longer be forced into the sediment. The depth at this point was recorded as the total depth, and the depth of unconsolidated sediments was calculated as the difference between the water depth and the total depth. The reference point for these measurements is the top of the dam at Page Ditch.

3.0 Bathymetric Data

Sediment thickness data collected on October 8-9, 1995 is presented below in the following tables. F.X. Browne, Inc. and I.S. & T. sediment thickness information is also presented on the enclosed plans entitled 'Feasibility Study vs. F.X. Browne, Inc. Sediment Thickness Measurements' and 'Lake and Channel Sediment Thickness Measurements'.

Lake Measurement Point	Water Depth (ft)	Total Depth (ft)	Sediment Thickness (ft)
1	8.80	17.30	8.50
2	4.00	8.00	4.00
3	4.00	6.50	2.50
4	5.00	6.50	1.50
5	4.00	5.00	1.00
6	4.00	7.00	3.00
7	3.50	3.50	0.00
8	4.30	7.00	2.70
9	5.00	6.00	1.00
10	4.00	7.10	3.10
11	5.50	10.80	5.30
12	5.60	12.00	6.40
13	7.00	15.50	8.50
14	9.50	17.70	8.20
15	10.50	22.30	11.80
16	7.30	13.50	6.20
17	8.60	20.20	11.60
18	4.30	11.00	6.70
	Average = 5.8	Average = 10.9	Average = 5.1

Channel 1 Measurement Point	Water Depth (ft)	Total Depth (ft)	Sediment Thickness (ft)
1	2.2	7.5	5.3
2	2.0	5.7	3.7
3	3.8	5.5	1.7
4	3.2	8.0	4.8
5	4.4	7.5	3.1
6	4.0	6.5	2.5
	Average = 3.3	Average = 6.8	Average = 3.5

Channel 2 Measurement Point	Water Depth (ft)	Total Depth (ft)	Sediment Thickness (ft)
1	5.0	7.6	2.6
2	5.0	7.5	2.5
3	5.0	7.7	2.7
	Average = 5.0	Average = 7.6	Average = 2.6

Channel 3 Measurement Point	Water Depth (ft)	Total Depth (ft)	Sediment Thickness (ft)
1	3.5	5.6	2.1
2	2.8	4.4	1.6
	Average = 3.15	Average = 5.0	Average = 1.85

Channel 4 Measurement Point	Water Depth (ft)	Total Depth (ft)	Sediment Thickness (ft)
1	2.7	5.8	3.1
2	3.4	7.5	4.1
3	4.0	6.9	2.9
	Average = 3.4	Average = 6.7	Average = 3.37

Channel 5 Measurement Point	Water Depth (ft)	Total Depth (ft)	Sediment Thickness (ft)
1	3.0	6.8	3.8
2	3.3	7.2	3.9
3	4.5	5.5	1.0
4	3.6	6.1	2.5
5	3.7	7.5	3.8
	Average = 3.6	Average = 6.6	Average = 3.0

From 1986 aerial maps provided by the Shipshewana Community Lake Improvement Association on October 7, 1995, an updated lake outline was produced. The areas of the lake and the five channels were measured as follows:

	Measured Area (ft^2)
Shipshewana Lake	8,916,000
Channel 1	57,040
Channel 2	31,600
Channel 3	22,920
Channel 4	40,320
Channel 5	42,760

4.0 Calculations

The lake sediment volume and the channel sediment volumes were calculated by multiplying the average sediment thickness by the corresponding area of the lake or channel. Sediment volume calculations are presented below.

Lake Sediment Volume Estimate:
(5.1 ft)(8,916,000 ft^2) = 45,471,600 ft^3
= 1,684,133.3 cy

Channel 1 Sediment Volume Estimate:
(3.5 ft)(57,040 ft^2) = 199,640 ft^3
= 7,394 cy

Channel 2 Sediment Volume Estimate:
(2.6 ft)(31,600 ft^2) = 82,160 ft^3
= 3,043 cy

Channel 3 Sediment Volume Estimate:
(1.85 ft)(22,920 ft^2) = 42,402 ft^3
= 1,570.4 cy

Channel 4 Sediment Volume Estimate:
(3.37 ft)(40,320 ft^2) = 135,878.4 ft^3
= 5,032.5 cy

Channel 5 Sediment Volume Estimate:
(3.0 ft)(42,760 ft^2) = 128,280 ft^3
= 4,751.1 cy

<u>Total Channel Sediment Volume Estimate</u>:
(199,640 + 82,160 + 42,402 + 135,878 + 128,280 ft^3) = 588,360 ft^3
= 21,791 cy

<u>Total Sediment Volume Estimate (Lake and Channels)</u>:
(1,684,133 cy + 21,791 cy) = 1,705,924 cy
= 46,059,948 ft^3
= 1057 ac-ft Say 1060 ac-ft

The required sedimentation basin volume was calculated based on a bulking factor of 1.0 (Herbich, 1992). A bulking factor is a ratio of the volume of dredged material in a containment area to the volume of in situ sediment.

<u>Required Sedimentation Basin Volume</u>:
(1060 ac-ft)(1.0) = 1060 ac-ft

5.0 Conclusions

The sediment volume in Shipshewana Lake is estimated at 1,684,133 cubic yards, the sediment volume in the five channels around the lake is estimated at 21,791 cubic yards, and the required sedimentation basin volume is estimated at 1060 ac-ft. International Science & Technology, Inc. calculated a sediment volume estimate of 551,357 cubic yards. The sonic method of measurement, the use of an outdated lake outline, and the preliminary nature of the report from which the I.S. & T. volume was taken all contribute to the discrepancy between the sediment volumes. More extensive bathymetric mapping is needed to calculate a more accurate sediment volume and eliminate the discrepancy between the sediment volumes.